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THESIS

MICROELECTRONIC OBSOLESCENCE MANAGEMENT

by

Daniel S. Beck

June 2003

Thesis Advisor:	John Dillard
Second Reader:	Richard Amos

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MICROELECTRONIC OBSOLESCENCE MANAGEMENT

Daniel S. Beck
DB-IV, United States Army
B.S.Chemical Engineering, University of Pittsburgh, 1985

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June 2003

Author:
Daniel S. Beck

Approved by:
John Dillard
Thesis Advisor

Richard Amos
Associate Advisor

Douglas Brook, PhD
Dean, Graduate School of Business
and Public Policy

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ABSTRACT

The ability of the Department of Defense to execute its mission is directly dependent on the capability to produce and maintain weapon systems. Rapid advances in technology have been instrumental to the development of highly efficient and capable systems. However, they have also increased the rate at which electronic part manufacturers change product lines resulting in the Department of Defense's increasing dependence on obsolete electronic components. The objective of this thesis is to provide a viable tool for managers to eliminate, mitigate, and proactively manage the growing obsolescence problem. The thesis will define obsolescence, provide a comprehensive discussion of ongoing obsolescence initiatives, and provide a systematic approach to manage microelectronic obsolescence. The thesis will also explore and provide recommendations to address the increasingly common scenario where an ongoing weapon system production program receives little or no notification of a part going out of production.

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TABLE OF CONTENTS

LIST OF FIGURES

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I. INTRODUCTION

A. STUDY FOCUS

The Department of Defense (DOD) has a mission greatly dependent on the weapon systems under its control. These systems have historically taken years to develop and produce and remain in service typically for decades. The industrial base during this extended period evolves to embrace new technologies. However, a technological revolution has caused the rate of evolution to increase substantially. The result is that DOD finds it increasingly difficult and, in some cases, impossible to obtain parts necessary to produce and maintain weapon systems.

B. OBJECTIVE

The objective of this research is to characterize the growing problem of microelectronic obsolescence and develop a systematic approach that weapon system managers can use to manage or mitigate the problem. The study concentrates on situations in which the manufacturer provides limited or no notification that it will cease production of an electronic component used to produce the weapon system. The thesis makes recommendations that program offices could implement before a manufacturer notifies them of their intent to discontinue or change product lines. Implementation of these recommendations would provide an institutionalized proactive management system instead of the traditional reactive obsolescence management, greatly reducing the probability of unexpected manufacturer notification. This approach, including the steps to

identify the problem early, should also result in an overall decrease in the impacts currently experienced by DOD programs.

The thesis also considers the current procurement climate as it relates to obsolescence. It will specifically focus on the regulations that preclude procurement of parts needed to ensure uninterrupted end-item production.

The thesis is organized as follows: Chapter 2 provides a comprehensive understanding of the problem; Chapter 3 presents the data from relevant sources; and Chapter 4 provides an analysis of the data followed by Chapter 5 that provides conclusions and recommendations.

C. RESEARCH QUESTIONS

The primary question this thesis will address is: What actions should be taken to allow successful management of microelectronic obsolescence? Additional questions include:

1. What problems result from microelectronic obsolescence?

2. What should be changed in the acquisition process to support microelectronic obsolescence management?

3. What steps can a program office implement to manage microelectronic obsolescence?

4. What can new programs do to minimize the impact of microelectronic obsolescence?

5. What commercial tools are available to manage microelectronic obsolescence?

6. What resources are available with the U.S. Government to address microelectronic obsolescence?

D. METHODOLOGY

Industry has and continues, at an increasing rate, to progress technologically. This progression, along with the extended length of time DOD historically needs to develop and retain fielded systems, results in DOD’s growing inability to obtain needed but discontinued microelectronic parts. This study concentrates on addressing program managers’ problems with discontinued parts. Data derived to support this thesis were obtained from interviews with DOD and industry representatives including representatives from Rochester, Landsdale, Diminishing Manufacturing Sources (DMS) teaming group, and the Defense Microelectronics Activity (DMEA). Legal personnel working in the DOD also provided information. Information also was obtained from numerous written sources including; journals, DOD personnel, DOD sponsored websites, and DOD pamphlets. The reader is assumed to have a strong background in Government procurement procedures and regulations.

E. SCOPE AND STUDY LIMITATIONS

The study will focus only on the current problems DOD managers are experiencing due to microelectronic obsolescence. Conclusions and recommendations support only DOD managers and their industry counterparts. This thesis will only address the current procurement rules impeding program managers. It will address the situation when redesign is required to eliminate an obsolete component and the redesign effort spans two or more years. The study will include a review of some but not all of the tools

currently available to aid in the management of obsolescence and include a discussion of some of the obsolescence resources available within DOD.

II. BACKGROUND

A. INTRODUCTION

Program managers are facing a growing problem: microelectronic obsolescence. The problem is not new. Managers have been responsible for resolving this problem for decades. However, the magnitude of the problem continues to increase.

Historically, obsolescence has occurred after completion of or well into the production phase of the program. Unfortunately, however, obsolescence is becoming prevalent during system development and the initial stages of production. [Ref. 1: p. 2] Irrespective of the program phase, the underlying problem remains the same.

This chapter provides a discussion of the underlying reasons for obsolescence and its impact on the DOD.

B. PROGRAM LIFE CYCLES

Historically, systems have progressed through numerous development stages including engineering and manufacturing development followed by production and, ultimately, sustainment. The formal guidance outlining the steps for weapon system development has changed, but the underlying intent has not. The overall objective of the development phase was to test, mature, and verify a producible design before proceeding into production. Design during this effort typically considered using products that were readily available from the commercial market. The design process included specific steps to evaluate parts in order to help ensure that suppliers would continue manufacturing

parts needed to support the program. Commercial electronic products historically had life cycles of approximately ten years. [Ref. 2: p.18]

The life cycle, from a weapon system designer’s perspective, began with the initial availability of the part to the point at which the industrial base no longer supported it. The part was considered obsolete when the original manufacturer or after-market source, no longer would supply it. However, technological changes are accelerating and substantially compressing the life cycle of commercial microelectronic parts. DOD’s system life cycle, unfortunately, far exceeds that of the typical commercial product. Figure 1 depicts this life cycle mismatch.

Product Life Cycles

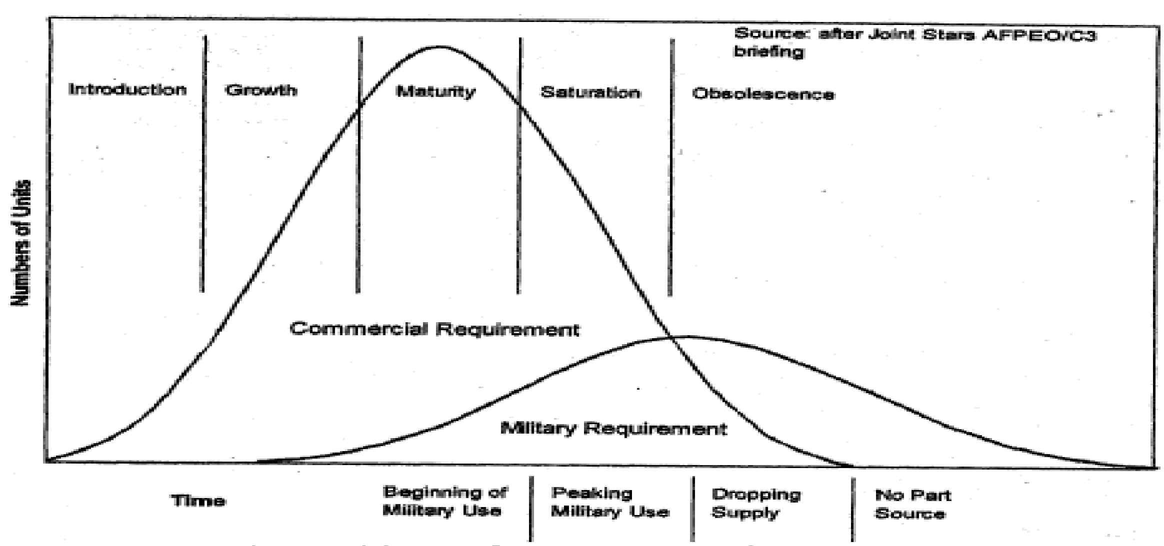

Figure 1. Product Life Cycles. From Ref 3: p. 35

The difference between the commercial and military product life cycles, as depicted in Figure 1, although not definitive, illustrates the magnitude of the problem. Although the problem is currently not insurmountable, one

needs to consider that the two lifecycles appear to be growing further apart, thus exacerbating the current problem [Ref. 4: p. 74]

C. DOD INITIATIVES

DOD has taken steps to minimize the mismatch between commercial and military product life cycles. These steps include greater emphasis on utilizing Commercial Off the Shelf (COTS) hardware, reliance on performance-based procurements, designs using open architectures, parts standardization and the initiation of numerous pilot programs. (Ref. 5: p. 1] These positive steps, though, have not eliminated the problem. DOD will need to implement additional changes to further address the issue.

1. Transistors

One way to gain a better appreciation for the life cycle of a part is to look at it from an historical perspective. Consider, for example, the basic transistor, an electronic component conceived in 1948. [Ref. 6:p. 82] The initial part, though not highly efficient by current standards, changed the direction of technology and industry. Systems were no longer designed using vacuum tubes, but were produced as solid-state devices using transistors.

Since introduction of the transistor, industry has increasingly relied on this technology and has continued to refine the manufacturing methods to reduce its size and capability. The transistor, initially the size of a human fingertip, was, by the mid-1960s, capable of being produced the size of a grain of salt. Currently, chipmakers are capable of incorporating approximately seven million

transistors within less space than the original unit occupied. [Ref. 7: p. 72]

There is growing concern that the manufacturer’s ability to further reduce the size of transistors may be reaching its technological limits. Although technology may be limited by current manufacturing techniques, one can be confident that, sometime in the near future, the problem will be resolved or overcome by some new method or technology. This new method may be a refinement of the current process or may shift to another technology such as microscopic mechanical devices. [Ref. 8: p. 46]

2. Microprocessors

Transistors serve as the basic building block of the modern microprocessor. These devices are becoming indispensable in the design of most modern commercial and military products. Microprocessors, as shown in Figure 2, which have incorporated additional capacity at an exponential rate, illustrate the rapid advancement of technology.

Transistor Densities

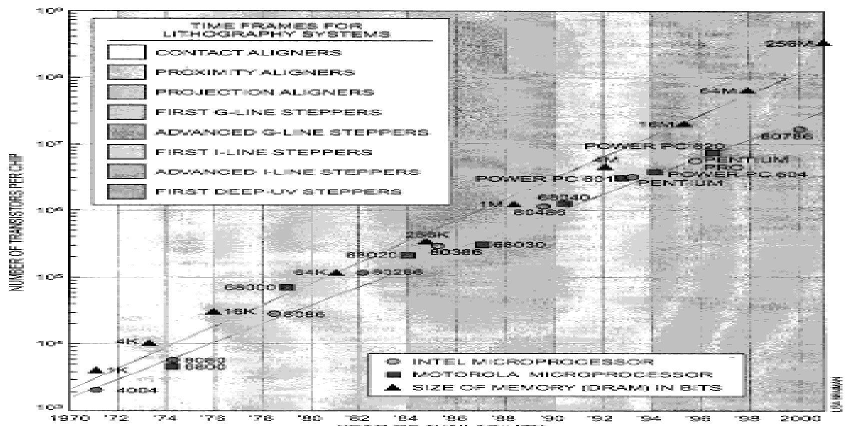

Figure 2. Transistor Densities. From Ref 7: p. 71

Microprocessors have changed significantly since the early 1970s, and their use both in weapon systems and in commercial products has increased substantially. The rate of evolution or growth of microprocessors follows Moore’s Law. Gordon Moore, a co-founder of Intel, predicted that the number of transistors on a microchip would double approximately every year-and-a-half. This prediction, which has shown itself to be fundamentally sound, has been deemed Moore’s Law. [Ref. 9: p. 32]

Due to the microprocessor’s ever-growing capability, planes, missile systems, and even cars now use multiple microprocessors per end-item to provide greater control, efficiency, and value to the product. This dependency on the microprocessor, and on rapidly changing capabilities and technologies in general, is the basis for the current dilemma DOD faces.

D. DOD AND THE COMMERCIAL MARKET

DOD’s dependency on the commercial market is being driven not only by the need for greater capabilities, but

also by DOD’s decreasing market share. Figure 3 depicts the shrinking share of the integrated circuit market that DOD represents.

DOD’s Market Share

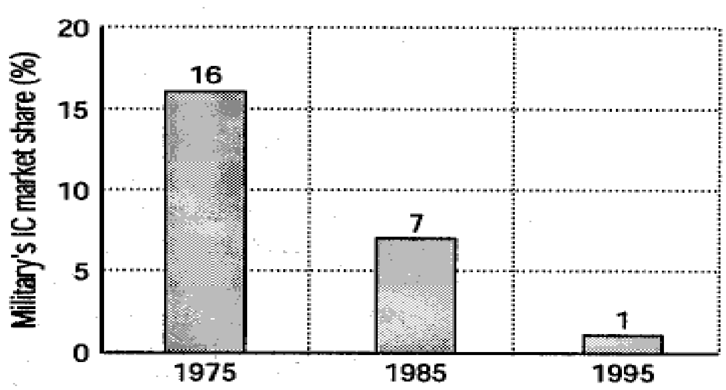

Figure 3. DOD’s Market Share. From Ref 10:p. 18

DOD’s share of the integrated circuit market decreased from sixteen percent in 1975 to one percent in 1995 and, currently, is less than one percent [Ref. 9: p. 369]. Due to the current economy, the limited DOD budget, and the increasing complexity and cost of weapon systems, there is reason to assume that this trend will continue. Figure 4 further illustrates the historically diminishing and insignificant percentage DOD represents and the distribution of semiconductor usage by market.

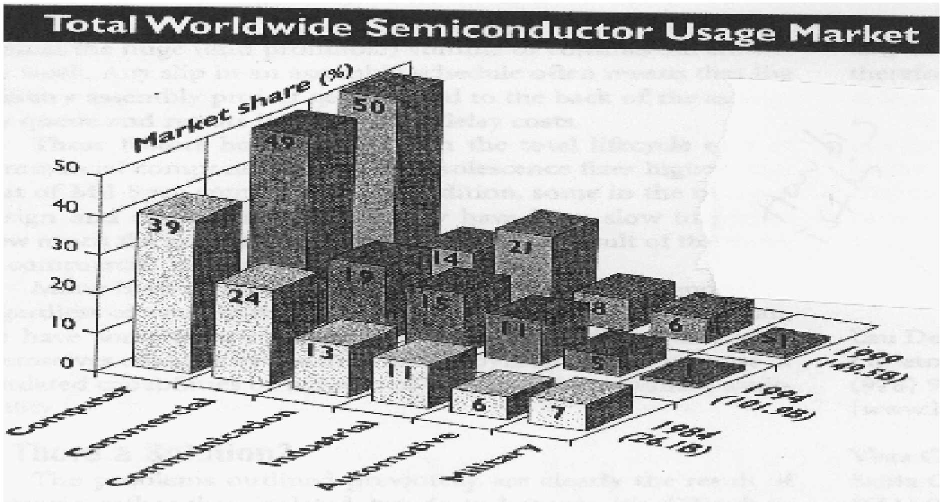

Figure 4. Total Worldwide Semiconductor Usage Market. From Ref 11: p. 80

At the heart of DOD’s obsolescence problem are market globalization, the substantially larger commercial market, the corresponding potential for profits, and the rapid change in technology that mirrors Moore’s Law. The DOD may need several thousand parts per year across all production and support programs. However, DOD, with its relatively small or insignificant overall parts requirement, has to compete with the telecommunication market, the computer market, and other commodity markets that annually require millions of parts representing quantities that are orders of magnitude more than required to support US weapon systems. DOD’s diminishing parts requirements correlate to the historically diminishing DOD market share. [Ref. 4: p. 74]

Since the DOD reflects a negligible and shrinking percentage of the potential overall production requirements, manufacturers necessarily concentrate on the commercial sector to provide the required return on their substantial investment. Commercial manufacturers, in many cases, no longer even consider military requirements, which

means that the DOD has a negligible influence on manufacturers to continue production of small quantities of obsolete or specialized products. Since the commercial sector controls the market, the DOD has few options and must take steps to assimilate the current market conditions into its long-term planning.

Additionally, since numerous companies have chosen to concentrate solely on the commercial sector to avoid the cumbersome Government bureaucracy and maximize profits, one can assume that this trend most likely continue. Consequently, one can conclude that this will ultimately result in a very small number of suppliers dedicated solely or primarily to military requirements. Unfortunately, small specialty markets generally correspond to higher costs, which are in direct opposition to DOD’s goal, need, and initiative to develop and produce systems with less investment and lower unit production costs.

One other point to consider is commercial investment. Generally, manufacturers of electronic microcircuits are forced to invest substantial effort and capital to obtain the tools and facilities necessary to produce microelectronic products. Intel, for example, recently invested approximately $1.3 B in a new production facility. [Ref. 7: p. 61]

Industry will continue to invest and develop ways to produce and reduce costs in order to retain or gain market share and the corresponding profits. They will continue to obtain cost reductions by investing in research to find new or better ways to perform current activities or to come up with newer technologies. Although research continues with no guarantees that it will provide a return on the

investment, one can be sure that industrial advancements will be made resulting in changes to the product configuration. Assuming that technology continues to advance, two questions remain: How fast will this occur? How can DOD gain the greatest benefit from it?

E. GOVERNMENT INITIATIVES

In 1999, the Apache helicopter received Congressional approval of funds specifically earmarked to address processor obsolescence. [Ref. 4: p. 78] The F-22 annually spends millions to address obsolescence and major DOD contractors are becoming less willing to enter into contracts that do not include language protecting them from the potential impacts of obsolescence. [Ref. 1: p. 5] One way DOD is trying to capitalize on ever-changing market technologies is by increasing the use of COTS hardware. This philosophy was initiated by Secretary William Perry, who issued a directive reversing the previous reliance on military specifications to favor commercial standards. [Ref. 12] The philosophical intent was to follow the commercial market and capitalize on growing commercial capabilities to enhance the military.

The Government also has established the Diminishing Manufacturing Source (DMS) steering group to address the situation. Therefore, the growing obsolescence problem has not gone unnoticed and will need to receive additional emphasis and attention in the future.

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III. DATA

A. INTRODUCTION

Is obsolescence a significant problem? The DOD, as previously discussed, no longer controls or even has much influence on the microelectronics market since it reflects less than one percent of the overall market share. This negligible demand, coupled with the substantial and increasing weapon system life cycle, has resulted in DOD weapon system managers finding more and more of their microelectronic parts to be increasingly difficult to find. Additionally, DOD's mission has become more difficult to due to the increased pace at which technology has been changing and the corresponding rapid turnover of microelectronic parts. The increasing life cycle difference, along with the small portion of the microelectronic market DOD commands, leads to the conclusion that microelectronic part obsolescence is here to stay and will grow unless there are some changes.

How big is the obsolescence problem for DOD? There is no definitive answer since each service and weapon system represents various levels and types of technologies in addition to each program independently managing problems associated with their system.

This chapter provides data on microelectronic market trends, DOD obsolescence initiatives, and DOD procurement and funding requirements. This information coupled with DOD specific examples of obsolescence impacts will demonstrate and provide insight into the breadth of the problem. This information will subsequently be used to

establish guidelines that weapon system managers can use to better manage their programs.

B. PROCUREMENT POLICY

The DOD has strict guidelines for procurement, which are delineated in the Federal Acquisition Regulations and supporting documentation. The basic philosophy of these regulations is to ensure that the end product or services are obtained in a fair and equitable manner. They also are in place to help ensure that funds are used specifically for the intended purpose. In addition to these regulations, the DOD developed a substantial and comprehensive list of military specifications that were used extensively in procurements to help ensure delivery of a robust and supportable system.

However, these guidelines and specifications were used during the period when DOD was at the forefront of technology, was steering the focus and development of technology and commanded a substantial portion of the electronics market. This situation has reversed itself however, and the commercial sector now controls and steers the development and focus of technology as shown in Figure 4.

The DOD has taken steps to enhance its capabilities by capitalizing on the technological progress of the market. At the same time, the DOD has instituted acquisition-streamlining initiatives in an attempt to reduce overall development, operation, and support costs. This focus on streamlining the procurement process began when Secretary William Perry, in 1994, issued a letter reversing the use of military specifications to favor commercial standards.

This, along with the Federal Acquisition Streamlining Act, has been the catalyst for ongoing acquisition reform. The spirit of this reform is to provide the commercial market greater license to use its inherent ingenuity, agility, and technical knowledge without hindrance from unnecessary Government constraints, resulting in higher quality, more capability, and lower DOD total life cycle costs.

1. Procurement Laws

a. *DOD 5002*

Although there have been many changes to the procurement process, the procurement system still contains rigid and stringent requirements. One applicable requirement is DOD 5002-R, which states that, for ACAT 1D programs,

> . . . long lead-time material or effort may be procured with advance procurement funds, but only in sufficient quantity to support the next fiscal year quantity end-item.

b. *Statute 31 USC 1502(a)*

Another applicable law is Statute 31 USC 1502 (a), which states:

> The balance of an appropriation or fund limited for obligation to a definite period is available only for payment of expenses properly incurred during the period of availability or to complete contracts properly made within that period of availability and obligated consistent with section 1501 of this title. However, the appropriation is not available for expenditure for a period beyond what was authorized by law.

c. *Statute 31 USC 1341(a)*

This law states:

> (a) (1) An officer or employee of the United States Government or of the District of

> Columbia government may not . . . (b) involve either government in a contract or obligation for the payment of money before and appropriation is made unless authorized by law . . . .

These laws, along with others, were enacted to ensure that funds were used as designated by Congress. They specifically state that funds cannot be used to support requirements beyond the immediate contract, helping to ensure and preclude misappropriation of funds.

2. Obsolescence Management Impediments

The spirit of the law is clear and, historically, has been very successful. However, these laws are becoming a serious impediment to weapon system managers. The problem stems from the inability of program managers to buy a sufficient quantity of parts going out of production to support the ongoing and near term production program.

The following example will illustrate the problem. Assume that a manufacturer of an electronic component plans to discontinue production of a microprocessor used to manufacture a military aircraft. Assume, also, that the Government has been made aware of the manufacturers' intent and has determined two technically viable solutions to the problem.

One potential solution would be to procure a limited quantity of microprocessors. The limited procurement would allow production to continue while the obsolete microprocessor was being designed out of the system. Typical redesign takes two or more years. However, the existing laws explicitly preclude the use funds to support out-year procurements. The program office, therefore, would have only one legal option, which would result in unavoidable and potentially very expensive program impact.

One might argue that the program office could have obtained authorization for advanced procurement funds to cover this situation. However, the advanced procurement funding would authorize procurement of parts to cover only one additional year beyond the immediate contract requirements. In many instances, this would not prevent a negative impact on the program since the necessary redesign would not be completed until well after the existing parts obtained with the advanced procurement funds had run out.

There would be another difficulty with using advanced procurement funds to resolve the problem. Advanced procurement typically requires a detailed description of the parts to be procured and is programmed well in advance of the requirement. Unfortunately, manufacturers usually do not provide much, if any, advanced notice of their intent to change product lines. Even when they provide notification, the information is provided only shortly before the change occurs. Using advanced procurement funds, though possible, would be an unlikely long-term solution since the overall budgeting cycle would be to slow to provide a viable option.

The other potential solution, assuming that issues of legality could be overcome, would be to execute a life-of-type buy. The intent with this option would be to procure all the parts necessary to support the remainder of the program. This includes the remaining requirements to support end-item production, new spares production, repair of spares and, potentially, foreign military sales.

However, there are problems with this option. The first problem would be to accurately project the number of parts needed to support production. Major production

programs are required to develop long-term projections in order to support the planning and budgeting cycle. These plans include the projected end item quantities by fiscal year. However, these long-term projections routinely change for a variety of reasons to include shifts in DOD priority and sales to foreign countries. Irrespective, these program changes make it nearly impossible to make accurate predictions.

Additionally, it would be very difficult to accurately project the number of parts needed to support new spares production. The difficulty arises directly from the potential variability of the major items. This variability coupled with the uncertainty associated with additional potential sales to foreign nations, results in the certainty that any projections would, potentially, be grossly inaccurate. There remains one other consideration: obsolescence.

Assuming it was possible to accurately predict the quantity of parts required for the remainder of the program, there would remain the possibility that some other part used on the same assembly would become obsolete. However, obsolescence of another part on the same assembly would negate the benefits obtained from the life-of-type procurement. Unfortunately, the likelihood of other parts becoming obsolete is high due to the increasing rate that technology is advancing.

C. COMMERCIAL OFF THE SHELF (COTS) HARDWARE

Acquisition streamlining includes increased reliance on COTS products. The intent is to use the available and emerging commercial technologies, thereby reducing or

eliminating DOD’s need for expensive research and development. It should also help to provide soldiers with newer capabilities faster.

The philosophy has merits and may help to reduce the impact from obsolescence, but it is currently not the complete solution. One difficulty associated with COTS would be finding a product with the necessary functions that would not require substantial modifications or testing. The more daunting issue would be to find commercial products designed to withstand military environments.

The following example readily illustrates the point. One can currently obtain, for a reasonable price from various commercial vendors, a high quality computer with a high-speed microprocessor and numerous other features. The computer would provide the soldier the required functionality. However, this product was not designed to operate in freezing temperatures or in humid or wet environments, or to function after being dropped or transported over rough terrain. Use of this product in such a demanding environments would quickly eliminate any utility and negate all perceived savings and benefits.

Another concern with COTS is the product life cycle. Due to the increased rate of technological progress, the commercial sector assumes that product lives are generally limited to several years. They design products assuming that they will be replaced in the near future, while the military supports end-items for decades as indicated in Figure 5. [Ref. 13: p. A33-3]

DOD System Life

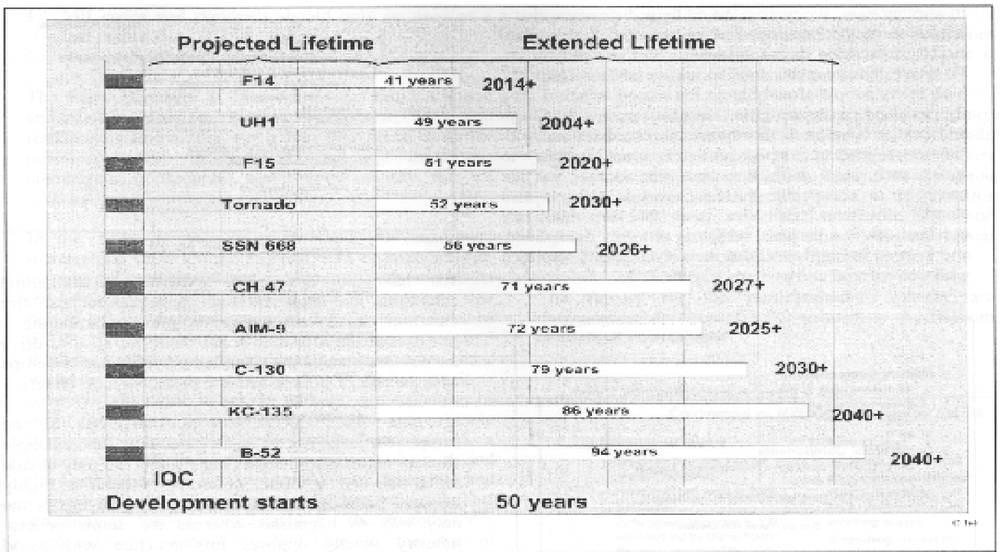

Figure 5. DOD System Life. From Ref 14: p. I-2

Another point to consider is that commercial products, even if they remain available for an extended period, evolve. There is no assurance that a product the DOD obtains one year will be available or identical to the item procured the next. Changes to the product may provide additional utility, but they may also cause problems if the product were integrated into a more complex system. Problems can arise from slight timing changes that make it impossible for microprocessors to synchronize or interface changes that result in system degradation or failure. The bottom line is that the DOD does not necessarily have insight into or control over the product configuration.

The lack of insight into product configuration could be partially resolved if the interfaces were stable to include all relevant technical parameters. However, even if the interfaces were stable, the program would still have to plan and budget for replacement of the COTs product in the near future since support of the legacy versions most likely would be unavailable or become overly expensive.

The overall result would be a continuous, incremental replacement of COTS hardware within the system. This would necessitate ongoing engineering type analysis to determine and verify system compatibility, including changes to other parts of the system to ensure successful integration.

1. Logistical Implications of COTS

The use of COTS hardware also affect the DOD Logistics system. Currently, item managers typically procure parts based on national stock numbers. The parts associated with these numbers generally have technical data packages that provide the necessary information for vendors to produce the item. Configuration control of COTS hardware, however, typically remains under the vendor’s control. As indicated previously, the COTS hardware, by definition, primarily supports the commercial market and usually evolves through periodic, pre-planned improvements. The manufacturer may take into consideration the desire for the new item to remain compatible with previously built hardware. However, the manufacturer, in most cases, would necessarily place substantially more weight on the needs of the commercial market rather than on those of the military.

The overall responsibility of item managers has therefore increased. They are now responsible for ensuring that an increasing number of commercial items work within the constraints of the overall weapon system. They may be able to accomplish this by working with the vendor who may provide the applicable technical information to support this. However, even if the vendor is cooperative, there remains the possibility that the delivered item would not function within the system.

Integration problems can occur if some or any of the critical parts were changed. The newer parts may have specifications identical to those of the replaced parts. However, there may be slight changes in the rise time or in the frequency response resulting in total or partial functional degradation. This loss of functionality may not be immediately obvious, but may manifest itself in periodic and apparent random failures. One could argue that this scenario is not new or isolated to COTs hardware. However, one could not argue that the magnitude of the problem has substantially increased since there is less insight and control of the configuration baseline. The increased use of COTS and the corresponding increased rate of technological change exacerbate this problem.

In addition to the reduced insight, vendors are becoming more specialized. This specialization has resulted in vendors and system integrators procuring more black boxes and integrating them into their end-products. Due to the increased specialization and focus on cost reduction, vendors are continuously integrating new parts into end- items. As a result, it is becoming increasingly likely that the item delivered to the Government will not be identical to what was procured before.

The only way to ensure that the procured item works would be to test it. The item manager would, thus, be responsible for performing a series of tests prior to accepting the hardware. The additional verification is time consuming and expensive.

D. CORPORATE SUPPORT

Although the Government may be unable to support future contracts by incrementally procuring parts that are being discontinued, it is possible that the system integrator could take the initiative to procure parts to protect the ongoing production program. However, recent direction from DOD specifically states that the Government should not encourage contractors to supplement DOD appropriations by bearing a portion of defense contract costs. [Ref. 15: p. 1]

This language refers specifically to research and development activities, but the underlying intention is applicable to production type programs as well.

This direction is not the only impediment to contractor investment. The DOD operates under constantly changing conditions. These changes affect priorities and, necessarily, program funding, which may increase or decrease substantially, making it nearly impossible to make accurate projections and, therefore develop long-term plans. This inability, coupled with the likelihood that the program may change, serves as a disincentive for the contractor to invest corporate funds to protect the program. Even if the contractor took the initiative to protect the program, the Government could not guarantee reimbursement. Although the part could possibly be used in another program, DOD’s use of specialized parts reduces this likelihood.

E. MARKET CONDITIONS

The DOD budget, though substantial, represents a small and decreasing portion of Government spending as shown in Figure 6.

DOD's SLICE OF THE DOLLAR

FISCAL YEAR	DEFENSE OUTLAYS AS A PERCENTAGE OF: FEDERAL OUTLAYS	NET PUBLIC SPENDING
2000	14.8	9.1
1999	15.3	9.4
1998	15.5	9.5
1997	16.1	9.9
1996	16.2	10.0
1995	17.2	10.7
1994	18.4	11.5
1993	19.8	12.4
1992	20.7	13.1
1991	19.8	12.6
1990	23.1	14.8
1989	25.8	16.5
1988	26.5	17.0
1987	27.3	17.6
1986	26.8	17.9
1985	25.9	17.6
1984	25.9	17.5
1983	25.4	17.3
1982	24.7	16.9
1981	23.0	15.8
1980	22.5	15.3
1975	25.5	16.5
1970	39.4	25.4
1965	38.8	25.2

Figure 6. DOD’s Slice of the Dollar. From Ref 16

The commercial market, on the other hand, has experienced significant growth during the last decade. Growth has been driven by technology that has increased the ease and ability to communicate resulting in a global market economy. [Ref. 17: p. 9] This global economy has lowered competitors’ entry costs and barriers, leading to a substantial increase in competition. This increase has provided the consumer with lower prices and greater choices. In this global, market-driven economy, DOD represents a small percentage of the overall commerce.

F. MICROELECTRONIC SUPPLIERS

Several representatives from industry were contacted to offer their perspective regarding obsolescence. There was general agreement that obsolescence has challenged and

will continue to challenge the DOD. This was also confirmed at a recent Defense Manufacturing Conference where several speakers noted that obsolescence was becoming a systemic problem [Ref. 18]. The speakers specifically noted that the Airforces’ F-22 program, the Navys’ DDX development program, and the Missile Defense Agencies’ programs were all necessarily focusing more on obsolescence.

The information provided confirmed that DOD represents only a very small portion of the semiconductor market and controlled less than one-half of one percent of the world market for the year 2000. It also confirmed the large and growing divergence between the life cycle of commercial semiconductors and the life cycle of military systems. Consequently, it was estimated that the percentage of obsolete parts in fielded military products was currently in the range of twelve percent, with after-market sources currently able to support approximately thirty-five percent of these obsolete parts. [Ref. 19]

The interviewees also indicated that sixty-five percent of the parts used in some fielded military systems were obsolete. Some suggested using part emulation to partially overcome this problem. After-market sources were taking action to develop teaming agreements with the original equipment manufacturers. The intent of these agreements were to help ensure that the technical data, tooling, and dies needed to produce the electronic parts were not destroyed at the end of the program but transferred to the after-market source.

The design of future semiconductors also was projected to increase the level of obsolescence. The majority of

semiconductor devices currently used within DOD hardware require five-volt power sources. However, the current trend in industry is toward more efficient devices that consume less power. Semiconductors previously designed to operate on the standard five volts are now designed to operate on a 3.3V power source, with plans to convert to devices requiring 1V or less. It was projected that industry would support the 5V devices for approximately another decade. However, newer devices were anticipated to have a markedly shorter product life. There also was concern regarding the environments in which commercial microchips were designed to operate. Commercial devices are designed to operate from zero to seventy degrees, Celsius, while the military typically requires a substantially greater range.

One other area of concern for DOD was the number of vendors supplying military-grade parts. The current trend is for companies to focus on the commercial market. Numerous companies, including Intel, Motorola, and Phillips, have stopped supplying military parts. The projections were that, unless the need for military products substantially increased, the number of vendors that supply military grade parts would continue to diminish.

1. Impact to Fielded Systems

The PATRIOT missile system is a fairly large and complex weapon that has been in the field for decades. It represents a typical fielded weapon system that consists of numerous major end items containing thousands of electronic parts covering a broad spectrum of technologies. Unfortunately, obsolescence has and will continue to

adversely affect this system. A recent study showed that approximately 10 percent of the overall system contained parts that are or are projected to be impacted by obsolescence [Ref. 20].

An example, that illustrates the impact obsolescence can and did have on the PATRIOT system, is the missile Fuze. This complex component was an integral part of the missile and relied on the availability of a variety of microelectronic parts to include hybrid microcircuits. These hybrids were custom parts used specifically for one purpose and were, therefore, available from only one qualified source. Toward the end of the missile production program, the hybrid manufacturer notified the program office of their intent to cease hybrid production.

Since PATRIOT was an international program, action was taken to notify all countries of the company’s intent to quit producing hybrids. In this case, the foreign partners as well as the US Government were provided the luxury of being provided notification from the manufacturer before the hybrid production line had been dismantled. This early notification provided the time needed for each country to determine what steps they should be take to protect their individual programs.

Unfortunately, after the company dismantled the hybrid production line, the requirement for additional fuzes arose. The program office had two choices. They could either qualify another source to manufacture the custom hybrids or initiate a redesign.

Before any decision or action was taken, the program office performed a study to characterize the risks

associated with both approaches [Ref. 21]. The study determined that, since the fuze had been developed numerous years ago, it contained numerous other parts that were or were on the verge of becoming obsolete. This risk associated with the other obsolete parts, coupled with the cost and difficulty associated with developing another qualified hybrid microcircuit source, led the program office to initiate a re-design of the applicable portions of the fuze. Due to the complexity and sensitivity of the fuze along with the magnitude of the re-design, the overall design and qualification effort took approximately three years at a substantial cost. [Ref. 22] Although this example may not represent the typical or average obsolescence scenario, it does clearly demonstrate that obsolescence can and does have a significant impact on hardware.

The PATRIOT program office, in an attempt to proactively manage the growing obsolescence problem, initiated a dedicated Integrated Product Team. The mission of this IPT was to develop and implement a process that continuously and systematically addressed obsolescence. Due to the sensitivity and importance of this problem, the international PATRIOT community agreed to permanently support and fund this effort. This cooperative effort resulted in the establishment of defined roles for the Government and the system integrator to jointly identify and address the problems resulting from obsolescence.

Over time, the objective of the IPT has not changed. However, its scope has expanded to include teaming with the logistics as well as the Aviation and Missile Command community with the intent to protect ongoing major end item

production along with current and, more importantly, projected spares procurements. This effort has identified numerous problems providing, the program office along with the logistics and international community, the necessary information and, in some cases, the necessary time to act individually or jointly to protect ongoing and projected efforts.

In addition to the efforts taken by the program office, the PATRIOT system integrator has recognized obsolescence as a chronic problem and has taken an additional step to combat it. The objective of this step was to develop a more efficient way to consistently address microelectronic obsolescence [Ref. 20]. This need resulted in the formation of a team that studied the overall problem from a system perspective.

This team subsequently developed a software tool that linked the systems' overall parts list to an in-house tool that identified and projected obsolescence. This new tool provided an automated method to efficiently analyze the entire weapon system from an obsolescence perspective. Exercise of this tool was envisioned to occur each time the system integrator responded to a request for proposal and should significantly reduce obsolescence-related problems before and after contract award.

Discussions have indicated that steps may be taken to enhance this tool by linking it to additional databases and predictors to provide more information that would expand and greatly improve the ability to project, identify, and proactively manage the problem. This insight should greatly enhance the capability to identify, project, and manage obsolescence.

The problem of obsolescence is unfortunately not isolated to PATRIOT. Numerous other systems, representing all of the military services, have experienced this problem. These systems include the Apache and Kiowa helicopters, the QAS-20X Anti-mine counter measure system, the F-15, and the TRIDENT weapon system [Ref. 23]. The potential cost associated with the impacts has been estimated to be in excess of 61M.

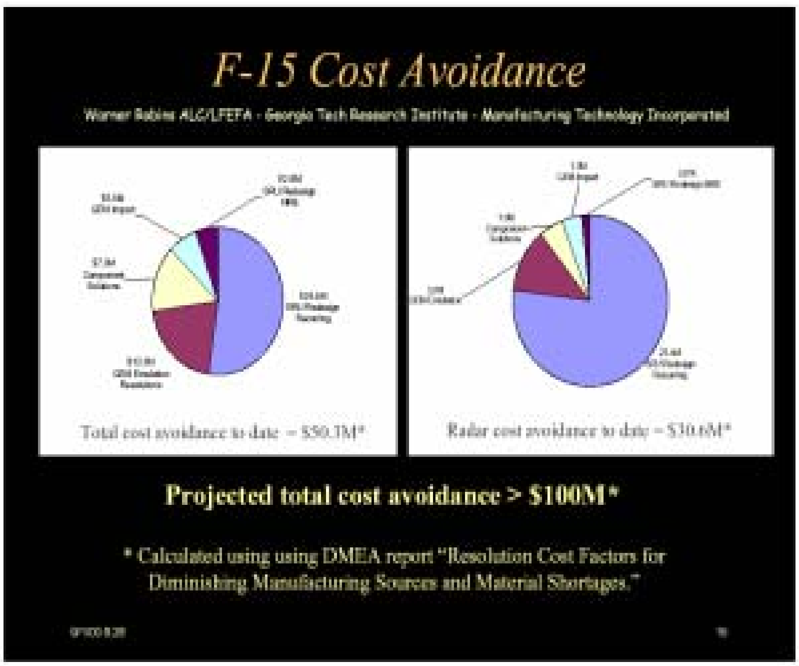

Figure 7. F-15 Cost Avoidance. From Ref 23

Another good example of the impact due to obsolescence is the radar system on the F-15. Obsolescence impacted the radar system resulting in the need for a redesign saving approximately 500M. [Ref. 24]

2. Impact to Developmental Systems

Obsolescence is, unfortunately, not isolated to mature systems. Programs that are in development or in the early stages of production are also being impacted. One such

program is the F-22 where action was taken to reprogram approximately 81M to address obsolescence. [Ref. 25} Another example is the PAC-3 missile that has recently completed development. This program, though in the very early stages of production, was allocated approximately 15M to address obsolescence and help ensure uninterrupted production. [Ref. 26] Development programs such as the Theater High Altitude Air Defense system and the Medium Extended Air Defense System have included or are working to incorporate specific language in the development contracts to address and mitigate the impact of obsolescence.

These examples demonstrate that obsolescence represents a problem for the Army, Navy, and Airforce in both fielded and developmental systems.

Another way to gain an appreciation for the size of the obsolescence problems is to consider the number of parts submitted to the Government Industry Data Exchange Program for resolution. The following graph shows the number is significant. [Ref. 27]

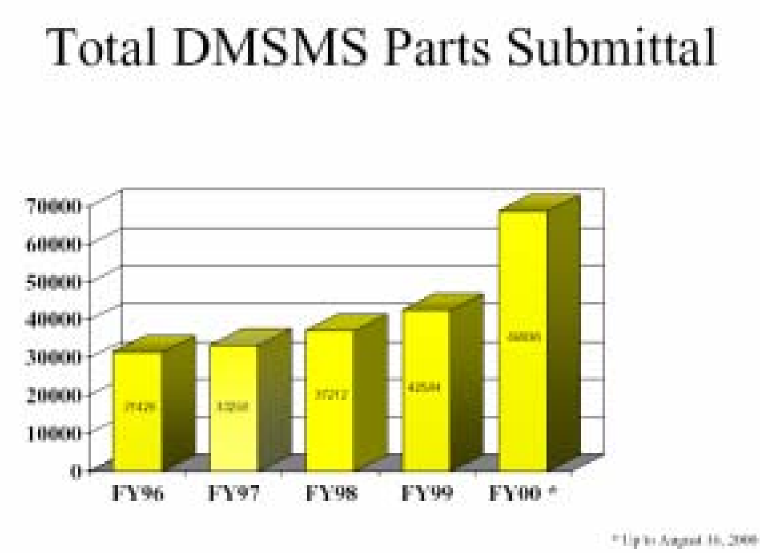

Figure 8. Total DMSMS Parts Submittal. From Ref 27

The following figure depicts the quantity of parts that obsolescence has impacted for three specific systems further supporting the premise that diminishing sources may affect approximately 5-10 percent of the parts within systems. [Ref.28]

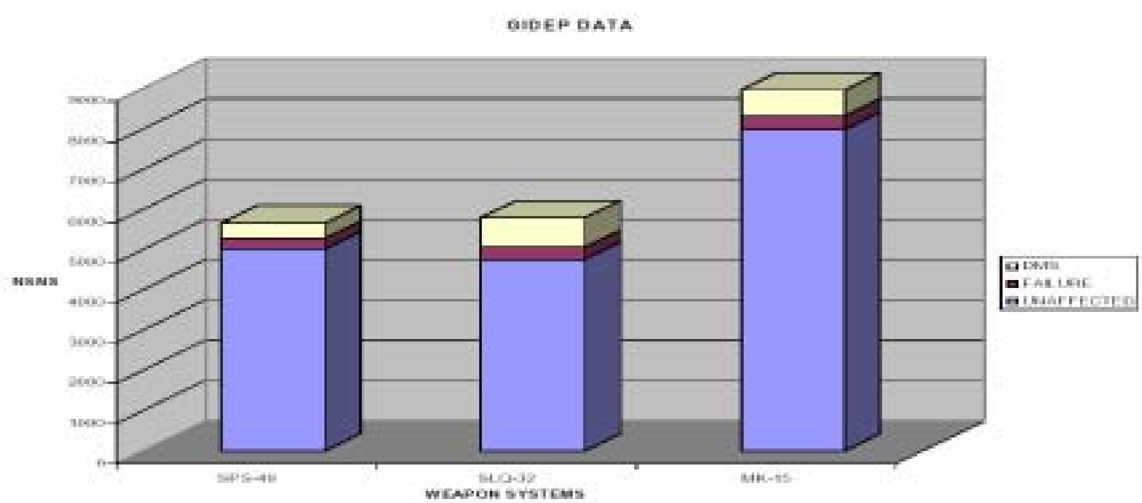

Figure 9. GIDEP Data. From Ref 28

It is to be noted that the average cost to redesign a board is $250,000. [Ref.25] Although no data was found to estimate the number of these parts that require redesign, one can safely assume that, as systems become older, the number of required redesigns increase along with the associated design costs. Additionally, even if redesigns were not required, there were costs associated with finding, developing and implementing solutions.

The previous information further demonstrates that microelectronic obsolescence has adversely affected weapon systems in every phase of their life cycle representing every military service. It also has shown that the impacts are costly and therefore require intense management.

G. GOVERNMENT RESOURCES

1. Diminishing Manufacturing Sources (DMS)

The DOD and NATO recognized that changing technology would impact the ability of the services to produce and sustain systems. [Ref. 16: p. iii] This recognition led to the establishment of a formal organization to address obsolescence was a positive first step toward obtaining insight into and control over the problem. DOD 4140.1-R established the DMS steering group. The overall objective of DMS, as stated in AMC-P 5-23, is to

> support readiness by minimizing obsolescence/nonavailability problems in Army system/equipment.

The charter of DMS is very broad and encompasses weapon systems in all phases of the life cycle.

The DMS organization is led by the Air Force, with the Deputy Chief of Staff for Research, Development and Acquisition having the overall management responsibility

for this action within the Army. All services are encouraged to participate in this organization, and the DMS organization serves as the framework for the services to interact. More importantly, it provides a formal organization on which program offices can rely on for experienced support.

An important benefit of having a formal organization is the increased ability to obtain and consolidate information. This ability allows the working group to track trends and support a lesson-learned database from which other programs can benefit. The DMS serves as the formal mechanism for consolidating the services' problems and supports open discussions to foster common and efficient solutions.

Participants in the DMS initiative are not only Government organizations. Some are from microelectronic producers and major weapon systems integrators. Current industry participants include Raytheon, Boeing, Rochester, and Lansdale. The DMS serves as the forum for managers, producers, integrators, and suppliers to effectively and systematically exchange information and ideas.

The DMS group is only partially funded by DOD, but provides a viable forum for other Government organizations to interface and work with industry or program offices. One such organization is the Defense Micro-Electronics Activity.

2. Defense Micro-Electronics Activity (DMEA)

The DMEA is a Government sponsored organization with a far-reaching mission. Its efforts are concentrated specifically on microelectronics technology including

obsolescence, technology insertion, reverse engineering, and in-house microelectronic manufacturing capability. The DMEA also works to form partnerships with industry in an attempt to impede the spread and minimize the impact of obsolescence.

The DMEA has had experience in developing custom programmable solutions to resolve obsolescence. It also has developed working relationships with the Defense Logistics Agency (DLA), Boeing, General Dynamics, Lockheed-Martin, Raytheon, and TRW. These working relationships were developed so that all participants could remain abreast of technical trends and problems. They also provide the opportunity for participants to learn about and potentially capitalize on favorable solutions implemented by others. These alliances also allow companies, all facing similar problems, to consult with one another and find solutions more efficiently.

The DMEA recognizes that rapid changes in technology can impact fielded programs. One way DMEA has found to provide DOD some flexibility is its flexible foundry. This capability allows DMEA, assuming it has the appropriate dies and documentation, to produce quantities of microelectronic devices such as amplifiers, mixed signal application specific integrated circuits, and gate arrays. Although this capability may not be the ultimate solution for a program impacted by obsolescence, it could provide a limited number of parts to support the field or production line. These parts would provide the bridge to get over the immediate problem, allowing the program office additional time to develop and implement a long-term solution.

The DMEA also has experience in technology insertion and engineering analysis, capabilities that provide an additional avenue to address and potentially resolve obsolescence problems. DMEA may have the experience and expertise to reverse engineer a part or to develop a specification for a replacement part. The organization also provides guidance regarding insertion of newer technologies to replace logistically unsupportable hardware. The web site for DMEA is http://www.dmea.osd.mil.

3. The Generalized Emulation of Microcircuits

The Generalized Emulation of Microcircuits (GEM) program is a Government sponsored program intended to provide legacy DOD systems with a source of supply for parts no longer manufactured by industry. The program was initiated in 1987 and was implemented through an on demand contract in 1997. Emulation does not provide the identical part, but a part that has the same form, fit and function. This includes all the requisite testing to military requirements supported by a Certificate of Conformance.

Emulation can currently be applied to technology types including Resistor Transistor Logic, Diode Transistor Logic, Transistor-Transitor Logic, Schottky, Emitter Coupled Logic, N-type Metal-Oxide Semiconductor and Complimentary Metal-Oxide Semiconductor. Some of the general parameters that GEM can support include part power supply of twenty volts and pin counts up to forty-eight.

The GEM program also has an online listing of more than three hundred separate parts currently available. The listing, which is by part number, makes it possible to obtain hard to find parts. If a needed part does not

appear in this listing, one can potentially obtain a quote for manufacturing a separate part. The website for the GEM program is http://www.gemes.com/

4. Government Industry Data Exchange Program (GIDEP)

The Government Industry Data Exchange Program (GIDEP) is an activity developed to foster cooperation between the Government and industry. The program entails the sharing of information regarding development, design, production, and support of weapon systems. The sharing of information typically results in the issuance of an alert. This alert may notify participants of a technical issue with a certain vendor or part. All U.S. armed services, the Department of Energy, the Canadian Department of National Defense, as well as other U.S. Government agencies use this information. The corporate participants include Lockheed Martin, Raytheon, Boeing, and many others.

This program was initiated approximately forty years ago and has saved an estimated one billion dollars. In addition to notifying participants of technical problems, it also gives notice of a manufacturer's intent to discontinue part production. Program managers should use this information to reduce or eliminate program impacts. The website for GIDEP is www.gidep.corona.navy.mil/gidep.htm.

5. Tactrac and AVCOM

Several tools currently are available to help manage obsolescence. Two of these tools are Tactrac and AVCOM, which are databases related to microelectronic parts. Specifically, the data bases list parts according to their availability. Both use a prioritization scheme to reflect

the level of risk associated with each part. They use the colors green, yellow, orange, and red to represent increasing levels of risk.

These tools are intended to help determine the overall health of any program, assuming that the parts list were available. This would be accomplished by comparing the information in the database to the parts list; the resulting report would show the overall percentage of red, orange and yellow parts. This information could be an invaluable management tool in that it would enable managers to develop long term plans to sequentially address and eliminate obsolescence and the corresponding program risk. The website for these tools is http://www.tdmplus.com/.

IV. ANALYSIS

A. INTRODUCTION

The DOD has invested substantial resources in the development, production, and sustainment of weapon systems. These systems are needed for a variety of reasons, as are the systems currently on the drawing board or being under consideration for future development. Each of these systems or products depends on the commercial market for parts that are becoming obsolete at an increasing rate. Obsolescence, therefore, makes producing and sustaining a weapon system more difficult, expensive and, unfortunately, risky. This chapter analyzes the information presented in the preceding chapter. Chapter 5 provides conclusions and recommendations for program managers to consider.

B. MANAGEMENT

The program or system manager is primarily responsible for ensuring that the weapon system meets performance requirements and remains producible as well as supportable. No matter which of the numerous program management philosophies and styles are used to address system obsolescence, the bottom line still requires ongoing and proactive obsolescence management to mitigate or preclude program impacts.

One of the keys to successful management of any program or problem is information. Managers, therefore, need to become and remain informed. Although they can accomplish this by various means, managers must develop and institutionalize mechanisms within the organization to ensure that they obtain relevant information on a

consistent and timely basis. Managers need this information far in advance of any decisions, before there are any impacts on either the production program or the readiness of fielded hardware.

Obsolescence is an area in which managers must remain cognizant of industrial and technological trends as they relate to the hardware in their particular system. The data found in the literature and obtained from industry all support this assertion. The question then arises as to the steps program managers should take to systematically address and resolve obsolescence. The following provides the framework to address this question.

1. Information

As indicated previously, one of the first steps managers must take is to educate themselves. Obsolescence, although not a new problem, continuously changes from a technology perspective, requiring constant attention. A manager should initially obtain information and guidance from organizations with the necessary experience and expertise. Depending on the manager’s location, he or she may be able to contact an onsite-centralized organization responsible for obsolescence management. If this does not exist, the manager should contact the DMS steering group. The applicable website was provided in the previous chapter.

2. System Technology Evaluation

After obtaining the requisite information and understanding, the manager should then designate a central point of contact responsible for overall obsolescence management. This point of contact should begin the management effort by performing an evaluation of the entire

weapon system. The objective of the evaluation is to gain an overall perspective on the number and types of parts used within the weapon system from a technological era perspective. The next step is dependent on the acquisition phase of the weapon system. The following discussion focuses on systems in production or sustainment.

C. PRODUCTION AND SUSTAINMENT

1. System Obsolescence Evaluation

Systems in production or in sustainment typically represent mature technology. After determining the gross numbers and types of technologies, managers should perform a detailed analysis of the system from an obsolescence perspective at the piece part level. The analysis should include some type of risk rating or ranking system. The ranking system should address technological maturity to reflect the projected risk associated with the current and projected availability of each part. One way to develop a ranking system would be to develop a standardized, hierarchical, color-coding system where, for example, red means that a part is, or will shortly become, obsolete and green indicates no known problems with additional colors representing various levels of defined risk.

One way to effectively accomplish this is to use a commercially available tool such as Tactrac or AVCOM. These or similar tools, can provide the relevant information, including color-coding and ranking by various levels of risk. The ease of performing this effort depends directly on the type and amount of information the manager has, relative to the configuration.

If the program has control of or access to the technical data package that includes the detailed parts list, the evaluation can readily be accomplished. However, the manager may not have access to the detailed parts lists for all or some portions of the system. In these cases, the manager should contact the corresponding manufacturer or responsible commodity command to hopefully obtain the needed information or ascertain that an ongoing obsolescence management program is in place.

There is another possibility associated with the data. Acquisition-streamlining stresses procurement based on performance requirements. Consequently, unless the Government specifically purchased the technical data package, the applicable parts lists may not be available. There also is the possibility the data could be proprietary; that is, the vendor may not want to release the information for fear that it may end up in a competitor’s hands. Either way, the needed information would not be available. The manager would then have to work with the supplier to set up some type of agreement or contract to support both immediate and future obsolescence analyses and programs.

Another consideration for the obsolescence management program is the media used to store the data. While older systems may have data available only in hard-copy format, newer systems should have the data in digital format. If the data were available in hard-copy format only, the effort to characterize the technology using computer-based tools would be very arduous and, potentially very large, depending on the complexity and size of the weapon system.

The manager may need to convert the data to a digital format, which would allow the data to be manipulated faster and more efficiently. Converting the data to a digital format may initially be expensive, but would provide the means to more easily analyze and handle the data and substantially reduce the future resources needed to manage obsolescence during the life of the effort.

The results from the initial analysis would provide the manager with an in-depth obsolescence health report for the system. The next step would be to develop a prioritized list, beginning with the parts that are or are most likely to become obsolete. This list would form the basis of the obsolescence management plan used to develop a comprehensive program to incrementally and systematically address and eliminate obsolescence. After developing the priority list and the corresponding program, the manager would ensure, prior to any expenditure of funds or additional efforts, that the parts or affected systems at the top of the list would not be replaced by either a system upgrade or an updated version in the near future.

2. Obsolescence Options and Planning

Once an obsolescence problem arises, the manager should identify potential options to resolve the issue, assuming that some other upgrade would not solve the problem. Potential options include:

1. Procuring enough parts to protect the remainder of the program. This is referred to as a life-of-type buy.

2. Finding or developing an alternate source.

3. Authorizing use of parts that do not meet all current performance requirements.

4. Replacing the system with a commercial product.

5. Emulating the part.

6. Designing a replacement that eliminates the obsolete part or technology.

7. Cannibalizing parts from previously built hardware.

Determining the appropriate option should involve a detailed analysis, including: the length of time the system will remain in the field; the length of time before another upgrade will replace the problem part; the need for the solution to be backward compatible; and the overall estimated life cycle costs.

The cost of the option should, initially, receive the highest consideration in the analysis. Additionally, the analysis should take into account supportability issues, including considerations associated with long-term plans for organic or contractor logistics support and training. It also should consider other systems, both commercial and military, that use or plan to use the corresponding item. This would provide the opportunity to work with other users to obtain needed parts, jointly develop and share costs for needed upgrades, or jointly procure additional units to obtain reduced unit costs and potentially provide enough incentive for the manufacturer to continue limited production.

a. ***Life of Type Buy***

Procuring enough parts to cover the remainder of a program is the basic definition of a life of type buy. As discussed previously, there is a legal impediment precluding this from occurring for a production program.

This type of action, however, can alleviate problems associated with spares production. A life of type buy does not come without risk, however. The risk comes from the possibility that another part used on the same assembly might become obsolete. If this occurred, the utility associated with the lifetime buy would be negated.

b. *Alternate Source*

As indicated previously, a program could pursue several options once the original manufacturer no longer supported a part. One of these options includes finding or developing another source. This option could be pursued through the program office or the prime contractor.

If a manufacturer plans to cease production, the manager should make contact immediately to ascertain what the manufacturer would require in order to continue production. Assuming that the manufacturer's requirements were beyond what the Government deemed reasonable, the manufacturer would then be asked to provide or sell the technical data, along with the supporting production hardware, tooling and test equipment.

Another option would be to determine who the previous users of the part were and if they had excess inventories that they would be willing to sell. These users also might have information regarding other potential sources with disposable inventory.

If the original manufacturer were not interested in supporting future production, but provided the technical data, the next step would to review parts catalogs to determine if parts with similar parameters were available. The technical information could also be provided to DLA and

other obsolescence management sources to determine if they have already seen or resolved the problem.

If no other sources were found, the next logical step would be to determine if another manufacturer would produce the item. The technical data could be provided to potential manufacturers. The interested companies could then respond with information, including estimated lead-time, tooling, and qualification costs, as well as the unit production costs. This information would serve as a portion of the economic analysis.

The likelihood of finding an alternate source, however, is small. Most manufacturers concentrate on producing large volumes of parts due to the potential for large profits. Additionally, a large initial investment most likely would be required. This initial investment would cover the costs associated with developing and proving out the production process and serve to substantially increase the unit production cost, potentially negating the value of the option.

If no other sources or accessible inventory exists, then the next potential step would involve contacting after-market sources. An after-market source, in this case, consists of a small number of companies that specialize in obtaining excess inventory from the original manufacturer. They may also obtain the tooling, dies, and excess wafers to support the potential for future production. Two such companies are Rochester and Lansdale, which have been working within this niche market for numerous years. They, in a number of cases, may have inventory available to support a programs’ immediate requirement.

If the after-market source does not have an inventory of the needed part, they may have the capability to produce additional components by using the component dies/tools and information procured from original manufacturer. However, one would need to consider the costs associated with the commercial after-market sources as compared to the Government sources such as the DMEA which has the capability to manufacture parts through its flexible foundry. One should also consider the GEM program to determine if it has the needed parts on hand or has emulated it or an equivalent part in the past.

c. ***Reduced Requirements***

One of the primary tenets of acquisition-streamlining is to obtain hardware that meets but does not exceed a requirement. Military hardware, especially older systems, generally was designed with a substantial design margin. There is a distinct possibility that the part specified years ago could be replaced with something that meets a less stringent requirement without compromising system performance. One would need to verify this through an engineering analysis or test.

For example, assume that a part was used in a system that would be sealed to keep the relative humidity below 30 percent. Historically, the military would specify ceramic packages because they have proven to be very reliable throughout the life of programs. However, a plastic encapsulated microcircuit would most likely perform as well as the ceramic part in the low-humidity application. Although there is less data and experience to certify long-term reliable performance, these parts are less expensive and, more importantly, readily available.

This lower cost and greater availability has resulted in the increased use of commercial grade parts in military applications. Due to the small quantity of parts the military procures per year, one can assume that the availability of military-grade parts will continue to diminish forcing the DOD to increasingly adapt to using more commercial-grade parts. This adaptation will most likely result in reduced reliability and system longevity, coupled with increased sustainment costs.

d. *Part Emulation*

Emulation provides another viable option to resolve obsolescence. Through the previously mentioned GEM website, one may potentially obtain information relative to the availability of a direct replacement or information relative to an available part that could be used with minor changes within the system.

Although emulation may provide a solution, one would also need to consider the other parts used in the item with the emulated part. It is very likely that some of the other parts represent or use technology similar to or older than that of the emulated part, leading one to assume that the other parts may also become obsolete in the near future. If this were to occur, the costs associated with the emulation would have been spent unnecessarily.

The previous discussion generally assumes availability of technical information associated with the part, but this information may not always be available. In such a case, another potential option would be to reverse engineer the part. This, most likely, would be substantially more difficult and potentially impossible,

depending on the complexity of the part, but it has been done. One potential starting point for this effort would be DMEA.

e. *Redesign*

One of the final steps a manager should consider to resolve an obsolescence issue would be to redesign. Redesigns may appear simple, but, in reality, they typically involve substantial effort, time, resources, and risk. Concurrent with the redesign effort, the manager would need to ensure that legacy parts are available to support ongoing production and sustainment, with the understanding that the redesign effort would, most likely, take longer than originally scheduled.

Due to its costs and risk, redesign should be considered the last resort to resolve an obsolescence issue. Redesigns also uncover additional interface problems, along with a host of other technical challenges that result in substantial cost overruns and schedule slips. Redesigns are necessary and inevitable, but must be approached with substantial caution.

f. *Cannibalization*

The concept of reusing parts from previously built hardware is not new. It may be applicable to some systems, but should be used with caution. If the part is to be used in a non-mission critical system, the approach may be suitable. However, due to the uncertainty associated with the type of environments a part has seen and the amount or type of use the part has experienced, a used part should not be considered for any critical systems unless there are no other options.

D. DEVELOPMENT

Systems that are in development and moving toward the production phase should be examined from an obsolescence perspective at the onset of the program. Unfortunately, this has become necessary due to the increased rate of obsolescence. This issue was adeptly captured by two statements':

> If it's in production it's obsolete" and " Once it's in production it's obsolete [Ref.13: pp. 1-2].

Although these statements refer to production, obsolescence has now become an issue during development, as well. [Ref.18: p.2] Initially, the obsolescence program would be used to increase awareness and, if necessary, educate the development team. It should subsequently develop into an integral part of the design, production, and sustainment programs.

The DMS organization has developed some suggested steps for programs in development. These steps include suggested language for development, as well as production type contracts. DMS also supports the assertion that development of an active obsolescence program would help to ensure a viable production program that would be less impacted by obsolescence.

After implementation of an obsolescence program, it is recommended that all proposed parts be systematically and periodically reviewed, prior to and after being specified, to ensure that the industrial base is likely to support the technology for the foreseeable future.

E. OBSOLESCENCE MANAGEMENT HIERARCHY

Managing obsolescence requires remaining cognizant of ongoing industrial and technical trends; developing and executing time-phased program to keep the weapon system supportable; and quickly resolving problems associated with little or no warning of manufacturers' intent to quit production of a part. The program manager and the industry counterpart necessarily support this process on a continuous basis.

There are no set rules associated with obsolescence management, but a manager should pursue a best-value approach. This approach generally means the low-cost solution, but other factors must be considered. The order of preference for the options discussed above, beginning generally with the lowest-cost, lowest-risk approach is:

1. Life-of-Type buy
2. Reduce part performance requirements
3. Finding another source
4. Developing another source
5. Emulation
6. Redesign
7. Cannibalization

There may be circumstances making one or more of the options impractical. However, this ordering provides a viable starting point.

F. PROCUREMENT OPTIONS

The laws associated with procurement have been shown to be an impediment to production programs. This impediment stems directly from law that precludes managers from procuring parts that would not be available in the near-term. This limit on managers' ability to react efficiently should be resolved. The only legal option available would be to pursue advanced procurement funds. Although theoretically possible, the process and time required toreceive approval typically does not support the time constraints associated with the current need.

Managers need the flexibility to quickly evaluate and, if appropriate, to procure the quantity of parts needed to sustain and protect their programs. One risk associated with this option is that an excess of parts might be procured. However, when one weighs this against the costs of the above-mentioned options, the viable answer is to modify the existing regulations to provide managers the needed flexibility and to reflect the intent and spirit of acquisition-streamlining.

One potential way to gain additional flexibility would be for Congress, in the appropriation language, to specifically authorize a small percentage of additional funds to be used to support obsolescence-related actions. This funding should include consideration for annual redesigns, as well as limited and life of type procurements. To help ensure that the funding was not abused, the applicable service or the procuring activity could monitor the actions. The program office also could be required, prior to any procurement of an obsolete part,

to provide a detailed justification showing the options and associated costs. This could be reviewed and approved at various levels of authority. The only requirement would be to accomplish the overall action and ultimate approval in a short period of time.

Another possibility would be to use the currently available infrastructure to manage the effort. As an example, DMS or DMEA could be authorized to fund emergency procurements if they were justified. The governing organization could review and, if appropriate, authorize the action.

There also is the possibility that DMS or DMEA could delegate this authority to offices responsible for obsolescence located at major subordinate commands. These satellite offices could be delegated the responsibility and authority, up to a designated single or annual procurement level, to authorize procurement of parts becoming obsolete.

The additional funding to support the infrastructure and the review cycle could come from Congress or the program offices that use the service. Requiring the users to pay for the service would help ensure an efficient system and quickly show the community support for the overall obsolescence initiative.

Another option that could provide additional flexibility, assuming that Congress did not change the laws or provide additional flexibility in the appropriation language, would be to delegate overall responsibility to program offices. This would include the ability to procure parts with the understanding that the funds used would be reimbursed, assuming it was justified. Justification could

be provided to the governing organization as previously discussed. Numerous possibilities and variations could be developed to support this concept.

What other steps could a program take to protect itself? Pursuing a multi-year procurement for the end item would allow procurement of parts to support numerous years and, more importantly, provide program stability. This stability would serve to reduce the number of vendors that cease parts production. It would also provide the flexibility to procure parts in more economical quantities.

The multi-year contract should require the prime contractor to monitor the vendor base from an obsolescence perspective. Historically, prime contractors determined that parts were no longer available when they released heir annual purchase orders. Due to the dynamic nature of the microelectronic parts industry, one could require, through the contract, a semiannual evaluation of the microelectronic vendor base. This would require funding up front, but it would provide valuable information and, most importantly, provide additional time to address an obsolescence issue.

If a multi-year contract is not feasible and no other flexibility is provided, then the program should try to annually obtain authority to procure a limited quantity of critical parts, including those that are projected to become obsolete. This could partially be accomplished through the use of advanced procurement funds. Although this action would not provide the security of a multi-year contract, it would give managers additional time to address a problem.

One final area that deserves greater emphasis is the potential of additional DOD partnering with allied nations. Some efforts have been taken to work with the international community, but the effort could be expanded. This would provide greater opportunity for all affected parties to work cooperatively. This cooperative effort could decrease costs for all participants, eliminate duplicate efforts, and increase the probability of finding an alternate source or solution.

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V. CONCLUSIONS AND RECOMMENDATIONS

A. INTRODUCTION

Microelectronic obsolescence is a phenomenon that results from technological advances. The increased rate of these advances has provided DOD with the potential to more efficiently and economically project greater defense capabilities. However, it also has made it increasingly difficult to obtain the parts needed to produce and sustain weapon systems. In addition to the problem of obtaining the necessary parts, program managers are permitted to buy only those parts needed for immediate use and are, in some cases, precluded, by law, from buying enough to ensure uninterrupted future production.

B. CONCLUSIONS

Although the problems caused by obsolescence are not new, they are becoming more prevalent for two reasons. The first reason is the amount of hardware DOD procures. In the past, DOD procured substantially greater quantities of microelectronic hardware that represented a substantially greater portion of the market. Now, however, it has been estimated that DOD represents less than one percent of the overall microcircuit market. Consequently, the commercial sector does not focus on DOD’s requirements, but on areas that are more profitable.

The second reason for the increased occurrence of obsolescence is the increased rate of technological advances. Today, the commercial market drives these rapid technological advances. Since the DOD no longer steers or controls the vast majority of research or technological

advances, it must take steps to ensure that legacy and future systems capitalize on commercially developed technologies and equipment. The rapid change in technology is exacerbated by DOD’s need to maintain fielded systems well beyond their intended lives, resulting in systems that remain active in the field for decades.

The DOD has taken steps to leverage the technological advances made in the commercial market by implementing acquisition-streamlining initiatives. These initiatives stress the use of COTS and open architectures that should help to partially alleviate the ongoing problem with obsolescence and help to reduce the amount DOD invests in research and development.

The DOD has taken additional steps to counteract the effects of obsolescence, among them the establishment of an obsolescence focal point, DMS, which is responsible for overseeing, administering, and leading the efforts associated with obsolescence. Other ongoing efforts include work being done by DMEA, DLA, and each of the services. The ultimate goals of these efforts are to allow programs to obtain identical parts, find alternate but functionally equivalent parts, jointly develop solutions, or to develop the ability to manufacture hard-to-find parts in order to avoid or delay the substantial cost and risk associated with inevitable redesign.

Sustainment and production programs rely on viable sources of parts. However, regulatory funding constraints prevent program managers from buying parts in sufficient quantity to protect ongoing production programs. This situation arises when a redesign program to replace obsolete hardware takes two or more years to complete.

Even with the redesign effort underway, the ongoing production program requires sufficient quantities of parts to sustain ongoing production. However, under the current system, advance procurement funds can be used to purchase only enough parts to sustain an existing production program for one year beyond the current year. Thus, managers cannot buy a sufficient quantity to maintain ongoing production.

Participation in DOD obsolescence initiatives is primarily voluntary. While individual managers choose to pursue these initiatives to resolve issues impacting their programs, there is no mechanism to coordinate efforts to resolve common problems. The reason for this appears to be funding. Additional funding would provide the means to establish a more centralized and comprehensive effort, including a centralized database. This database would, ideally, reflect all DOD programs at the microelectronic parts level. Such a mechanism would make it possible to efficiently identify all systems impacted by an obsolete part and to eliminate or greatly reduce the possibility of several programs simultaneously addressing the same problem.

This database would be a valuable resource for programs in the initial stages of system design or during the redesign stage. It would help to ensure that new designs did not contain microelectronic parts projected to become obsolete in the near future. The database also would allow program managers to identify industry trends in order to support long-term planning.

Although DOD has taken some substantial steps to address obsolescence, it should take additional steps by

working more closely with allied nations. There has been some effort in this area, but greater focus is needed. Some of our allies may be producing or have the ability to produce technologies that have been abandoned by the U.S. industrial base. Even if U.S. industry could still provide the technology, competition from a foreign source would likely result in reduced costs.

Allies also could offer financial support for the obsolescence programs. In addition to reducing all participants' costs for obsolescence initiatives and reducing or eliminating duplicate efforts, cost-sharing would help ensure that the U.S. and its allies are better capable of producing and supporting vital equipment during times of war or police actions.

The idea of cost-sharing also should be applied at the program level for program-specific issues. A reasonable portion of the costs should be borne by all nations that ultimately receive the benefits derived from the obsolescence program.

Another way that DOD could reduce cost would be to encourage major DOD contractors to consolidate their internal obsolescence efforts. DOD contractors, in general, have numerous stand-alone business sectors that use and rely on the same parts. However, each business sector, tends to address its own obsolescence issues. Consolidating or linking these efforts would help to streamline the overall process and eliminate redundancy. There also is the potential for separate companies to work together and consolidate requirements when buying obsolete parts to help reduce cost and convince manufacturers to produce limited quantities of older components.

C. RECOMMENDATIONS

Since it can be assumed that the problem of microelectronic obsolescence will continue to impact DOD, managers should establish obsolescence programs that become an ongoing and integral part of their programs' daily activities. The objective of these programs is to aggressively and proactively manage obsolescence to reduce the overall impact on DOD programs. Ideally, obsolescence programs should be established at the outset of a program, become very active during system design and development, and continue through the remaining life of the effort.

The obsolescence program should capitalize on the resources available within both DOD and industry, including access to no less than one commercial tool such as Tactrac. Tools such as Tactrac provide a risk assessment for parts that could readily be used to evaluate, categorize according to risk, and subsequently develop a sequential, part-by-part plan to replace or design out problem parts.

Initial efforts should include discussion with representatives from DMS and from other programs with ongoing obsolescence programs, local obsolescence experts, and relevant industrial resources. These discussions would provide valuable insight, guidance, expertise, and would serve as the foundation for a viable proactive obsolescence program.

In addition to working within the DOD, managers should require, as an integral part of applicable contracts, obsolescence assessments. This requirement would complement the ongoing efforts of program offices and DOD.

Relevant guidance regarding specific contractual language should be obtained from DMS.

Once an obsolescence office has been established, the manager should begin an analysis of the overall program from an obsolescence perspective. This analysis would provide a list of parts that are, or are projected to become, obsolete. Managers could then use this list to develop a time-phased plan to systematically address or replace the obsolete parts. Initial efforts should concentrate on parts that are currently obsolete and then address problems in descending order of priority.

Any solution must take into consideration economics. An analysis should be conducted for each part to determine the most cost-effective, long-term solution. The preferred orders of potential solutions, beginning with the lowest-cost approach, is as follows:

1. Life-of-Type buy
2. Reduce part performance requirements
3. Find another source
4. Develop another source
5. Emulation
6. Redesign
7. Cannibalization

Prior to addressing any obsolescence problem, the program should work with DMS or the command obsolescence representative to determine if other programs have previously addressed and resolved the problem. If others have already done so, the program should capitalize on their effort to quickly eliminate the issue. If others

have not resolved the problem, the program should identify other programs that use the same part(s) and investigate the possibility of sharing costs.

Once the initial obsolescence assessment has been completed, including development of the program to systematically eliminate obsolescence, the program office should maintain constant surveillance to identify additional obsolescence problems as early as possible. The obsolescence program should be a cooperative effort between Government and industry and provide a flexible and robust effort capable of meeting the ongoing needs of the program. The overall obsolescence program should include some form of continuous redesigns that takes into consideration the potential benefits of COTS and industry trends.

Funding will be required to support the obsolescence program, and to cover personnel, part procurement, redesigns, and contractor surveillance efforts. Managers, therefore, must project funding requirements well in advance of need and should include, as part of their annual budget requirement, funds to support the obsolescence efforts. They should also annually pursue, as part of the normal budgeting cycle, advance procurement funding for purchasing a small group of pre-selected parts ahead of the contractual need. This should help to reduce some of the program impacts and allow additional time to address and resolve know obsolescence problems.

Besides implementing strong obsolescence programs, DOD should pursue multi-year contracts, which would minimize the impact of obsolescence by allowing for economical order quantities and provide the benefits of a stable funding profile. This stability would give manufacturers some

incentive to remain in production, thus reducing or delaying obsolescence problems.

If a multi-year contract is not a viable option, the program office, along with its industry-counterpart, should identify and seek approval for an economical order quantity to cover several single-year, stand-alone procurement contracts. This would not eliminate obsolescence, but, like the multi-year contract, would serve to reduce or delay the impact.

In addition to the contractual options, production programs should be given additional flexibility to procure parts that unexpectedly become obsolete in order to ensure uninterrupted production. The added flexibility should permit the procurement of parts in substantial quantity to, if necessary, cover several years of production. This could be accomplished in several ways. The first and most expeditious method would be for Congress to authorize programs to buy quantities of parts going obsolete in excess of what is needed for the immediate contract. Congress could explicitly provide this flexibility in the procurement appropriation language. Congress could also take steps to add a law that provides this flexibility and delegates authority to the applicable acquisition executive, program executive office or program office.

Another method to achieve additional flexibility would be for Congress to change the language in several regulations and laws. The first change needed would be the elimination of the following phrase from DOD 5002: ",... but only in sufficient quantity to support the next fiscal year quantity end item." Another important change would be for Statute 31 USC 1502 (a) to exclude the sentence,

“However, the appropriation is not available for expenditure for a period beyond what was authorized by law.”

In addition to changes to procurement requirements, DOD should take steps to further centralize all efforts associated with obsolescence and should require all programs to participate in these efforts. DOD should develop a central database into which programs load their configuration baselines or, at least, their lists of known problems parts, and it should provide annual funding to support the ongoing efforts. This database could then be used to more efficiently identify which programs are, or will be, impacted by an obsolete part. It would also serve as a foundation for effected programs to cooperatively develop solutions and share investment costs.

Finally, DOD should take steps to work more closely and develop an ongoing obsolescence program with foreign allies. This would help to reduce the overall cost for each participant and provide another potential source of supply to supplement the US industrial base.

D. SUMMARY

Microelectronic obsolescence is not a new problem. However, its growing prevalence makes it increasingly difficult to maintain a viable production or sustainment program. Although obsolescence cannot be avoided, it can be managed by implementing a robust program to systematically address the problem. This program should consist of dedicated personnel working cooperatively with their industry counterparts, DOD organizations, and, potentially, foreign allies.

Besides the need for obsolescence programs, changes are needed in the procurement laws or appropriation language to allow managers additional flexibility to resolve the problems associated with obsolescence. Managers should pursue advance procurement funds or other applicable funding sources to proactively and systematically address and eliminate obsolescence. This problem will continue for the foreseeable future. However, with the appropriate attention, it can be managed.

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